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AN ECOLOGICAL STUDY OF THE ENDEMIC HISPANIOLAN ANOLINE LIZARD, *CHAMAELINOROPS BARBOURI* (LACERTILIA: IGUANIDAE)

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ABSTRACT. We studied the ecology and behavior of *Chamaelinorops barbouri* at two sites. *C. barbouri* has very specific habitat requirements: montane ravines with abundant leaf litter, well-shaded by intact forest canopy. It is an almost exclusively terrestrial lizard, preferring leaf litter in deep shade. Despite its non-basking, shade-loving habits, *C. barbouri* maintains its body temperature well above air temperature, and linear regression of body temperature and air temperature data yield a fairly low regression coefficient; this finding is surprising in comparison to the thermal biology of other forest-dwelling, non-basking anoles, and Greater Antillean anoles in general. We found *Chamaelinorops barbouri* to be cryptic, sedentary, and elusive, and thus difficult to study behaviorally. It is highly specialized ecologically, morphologically, and behaviorally for life in the leaf litter, much more so than any other anole.

INTRODUCTION

Since its discovery in 1919 by K. P. Schmidt, the anoline lizard *Chamaelinorops barbouri* has remained in animal of enigma. Over half a century passed from the time of Schmidt's (1919) description before the systematics and distribution of this endemic Hispaniolan anoline were worked out satisfactorily, and yet the precise type locality is still not known and probably never will be. This lizard has a unique vertebral column, not duplicated by any other vertebrate, of which the functional significance (if any) is still completely unknown (Forsgaard, 1983). Equally mystifying

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are the relationships of *Chamaelinorops*; it has been argued that the genus is either very derived (Etheridge, 1960; Wyles and Gorman, 1980), having arisen from within *Anolis,* or is very primitive (Williams, 1977; Case and Williams, 1987), indeed, the most primitive of living anoles.

Yet of all the enigmas of the biology of *Chamaelinorops barbouri,* we are most ignorant of its behavior and ecology. Our only information to date of *C. barbouri* behavior is limited to a single study of display behavior in captive males (Jenssen and Feely, 1991). No study has ever been conducted before on the ecology of *C. barbouri.* The sum of our knowledge in this area is limited to a few sentences on the preferred habitat (Thomas, 1966) and some remarks on the conditions under which eleven specimens were collected (Schwartz and Inchaustegui, 1980; Franz and Cordier, 1986). Our limitation in knowledge is primarily attributable to the inability of a non-native collector to procure a series of specimens. Only local residents of an area where *C. barbouri* is found are able to secure a series, usually with great ease. At the time of the most recent work on *Chamaelinorops* (Schwartz and Inchaustegui, 1980), a total of fifty specimens had been collected, of which the great majority (39) and the only large series (10) had been captured by natives.

Herein we report the results of an ecological study intended to elucidate some of the mysteries of the ecology and behavior of *Chamaelinorops barbouri.*

MATERIALS AND METHODS

A large series of *Chamaelinorops barbouri* can be obtained at a small settlement known to herpetologists as The Haitian Village and to natives as "Ande Javi," located about 15 km SE of the town of Cabral and near the city of Barahona in the Provincia de Barahona, Dominican Republic. We received as many as 75 lizards collected by village residents in a "lizard market" in a two-hour period, and subsequently had to turn away additional specimens. Whereas no non-native had ever been able to collect more than a few *Chamaelinorops,* and then only serendipitously, and because it was unclear where to search for these lizards, we located a Haitian Village resident familiar with *Chamaelinorops* to act as a guide and to demonstrate how to collect them.

Study Site. There are two areas in the vicinity of The Haitian Village where *Chamaelinorops* is most abundant. Both are close to the village, located in ravines sloping to a dry stream bed. The slopes have been cleared of most of the understory and planted with food plants under an intact mesic primary forest canopy (and hence much shade), and are covered by abundant leaf litter often interspersed with small, crushed limestone rocks.

The first site (1,000 m elevation) is called Caña Segudinas by natives. A small portion of slope on one side of a ravine has been burned out and planted over with *malanga*‘, a tuberous crop with large leaves. Penetrating further into the forest, one encounters the dry stream bed and mostly uncultivated ravine slopes where *Chamaelinorops* is found.

The second site (1,140 m elevation) is known by the villagers as Tejul. This site includes broadleaf forest, and an adjacent coffee plantation where the canopy is still intact and most of the understory has been cleared and planted over with coffee trees. As with Caña Segudinas, the area is a ravine whose slopes descend to a dry stream bed.

Methods. To collect *Chamaelinorops,* residents of The Haitian Village require only a short stick (about 2–3 ft long). The collector must walk slowly, brushing the leaf litter with the stick in moderately short, slow strokes while paying close attention to any movement. When encountered, the lizard betrays its presence by a short hop or run, followed by an abrupt stop or a dive beneath the litter. If not clearly sighted and kept track of during flight, *Chamaelinorops* is easily lost by dint of its superb camouflage and its ability to rapidly hide within the leaf litter.

Our study was conducted from 28 July 1985 to 4 August 1985. We logged 15 person-days during the study period, collecting data on 70 *Chamaelinorops barbouri.* The optimal time for observing *Chamaelinorops* was throughout the morning and into the early hours of the afternoon, and so most of our study was conducted between 0900 and 1400 hrs.

The study focused on three aspects of the biology of *Chamaelinorops barbouri*: (1) habitat preference; (2) thermoregulatory strategy; and (3) behavior. For habitat preference the “Rand census” was employed. The observer walks through the habitat, recording the height, diameter, and insolation of the perch where the lizard was first sighted (Rand, 1964). Perch height was recorded as "underground," "ground," or estimated to the nearest foot. Because *Chamaelinorops* is almost completely terrestrial, one of five categories was recorded for every ground observation: on dead leaves, under dead leaves, on bare earth, on rocks, or under rocks. For perch diameter, seven categories were used: underground, on rocks, on ground covered with leaf litter, on bare ground, trunk (perch diameter greater than three inches), branch (perch diameter between one-half inch and three inches), and twig (perch diameter less than one-half inch). For insolation, the amount of shade at the perch was estimated as one of the following: full shade, moderate shade, light shade, or unshaded. For thermoregulatory data, Schultheis quick-reading mercury thermometers were inserted into the cloaca as soon as possible after lizard capture in order to minimize hand contact with the lizard's body. Once sighted, *Chamaelinorops* was easy to capture; all lizards were captured within five seconds, eliminating the possibility of false body temperature elevation due to a protracted chase. The air temperature 1 cm above the perch site was then immediately recorded with the thermometer bulb shaded, after the bulb was completely dry. Cloacal temperatures were recorded for 64 of the 70 *Chamaelinorops* sighted. For behavioral data, individuals were often observed for several minutes before or after capture. Additional observations were also made on captive individuals maintained in a terrarium.

Thermoregulation was assessed by the method of Huey and Slatkin (1976), using the regression coefficient from the linear regression of body temperature and air temperature: a regression coefficient near 0 implies careful thermoregulation (body temperature independent of air temperature), whereas a regression coefficient near 1 implies thermoconformity (complete thermal passivity). A Spearman's coefficient of rank correlation of body and air temperature data was also calculated. There was no significant difference (t-test of the differences between two means, $P \gg 0.05$) between the body temperatures of adult males and adult females, and, although there was a significant difference between the body temperatures of adults and juveniles ($0.05 > P > 0.02$), the sample size of juveniles (3) was too small to be

TABLE 1. PERCH HEIGHT OBSERVATIONS FOR *CHAMAELINOROPS BARBOURI*. PERCH HEIGHT CATEGORIES: −G = UNDERGROUND; G = GROUND; ALL OTHER CATEGORIES ARE ESTIMATES TO THE NEAREST FOOT. (UNSEXED ADULTS = ADULTS OBSERVED BUT NOT CAPTURED.)

	−G	G	0	1	2	3	4	5
Males		35	1					1
Females	1	25	1			1		
Juveniles		2	1					
Unsexed adults		2						
Totals	1	64	3			1		1

useful; consequently all sex and age classes were pooled in the presentation of thermoregulatory data. The standard criterion of statistical significance was utilized ($P < 0.05$). All statistical tests follow Sokal and Rohlf (1981).

RESULTS

Observations at the two study sites indicate that *Chamaelinorops* has the following special habitat requirements: (1) An intact forest canopy providing abundant shade; (2) Abundant leaf litter; (3) Conditions (1) and (2) located in a ravine with slopes ending in a dry stream bed (the association with a dry stream bed in both of our study sites may have been a coincidental finding, but we never succeeded in finding *Chamaelinorops* in habitats meeting conditions (1) and (2) but not (3), and *Chamaelinorops* collected for us by residents from the Sierra de Neiba on the North Island of Hispaniola were always reported as having come from habitats exhibiting the above three conditions); (4) Montane elevations, usually about 1,000 m (but can range from 300 m to 1,710 m [Schwartz and Inchaustegui, 1980]).

Data on perch height (Table 1) indicate that *Chamaelinorops* is almost exclusively a terrestrial anole and not at all arboreal. *Chamaelinorops* was never observed in any type of situation that could be considered arboreal—trees, saplings, bushes, low vegetation, etc.—despite intensive searches for lizards in these situations. Although it is possible that *Chamaelinorops* was missed in arboreal situations due to its extremely cryptic appearance and

TABLE 2. TYPES OF TERRESTRIAL PERCHES CHOSEN BY *CHAMAELINOROPS BARBOURI.*[1]

	On rocks	Under rocks	On dead leaves	Under dead leaves	Bare earth
Males	1	1	24	5	5
Females	1	2	15	3	4
Juveniles			1	1	
Unsexed adults		1		1	
Totals	2	4	40	10	9

[1] Other terrestrial situations in which a single individual was observed: on a log, underground, on a dead banana leaf, within a pile of dead branches on dead leaves.

habits, lizards could never be induced to climb, even when placed next to or on arboreal perches and provoked to a state of severe alarm or agitation.

Chamaelinorops predominantly prefers ground covered with leaf litter (Tables 2 and 3). *Chamaelinorops* was observed on dead leaves more frequently than on all other terrestrial perches combined (Table 2). Similarly, the number of observations of *Chamaelinorops* on leaf litter exceeded the number of observations on all other categories of perch diameter combined (Table 3). In addition, no observations for the trunk or twig categories were recorded.

Chamaelinorops overwhelmingly prefers shady perches to sun-

TABLE 3. PERCH DIAMETER OBSERVATIONS FOR *CHAMAELINOROPS BARBOURI.* TR = TRUNK (>3″ IN DIAMETER); BR = BRANCH (½″–3″ IN DIAMETER); TW = TWIG (<½″ IN DIAMETER). (SEE MATERIALS AND METHODS SECTION IN TEXT FOR ADDITIONAL EXPLANATION OF PERCH DIAMETER CATEGORIES.)

	Underground	Rock	Ground covered by leaf litter	Ground	Tr	Br	Tw
Males		1	30	6			
Females	1	1	20	6			
Juveniles			2			1	
Unsexed adults			1	1			
Totals	1	2	53	13		1	

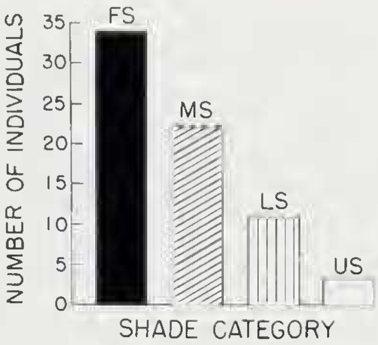

Figure 1. Shade category observations for *Chamaelinorops barbouri.* FS = full shade; MS = moderate shade; LS = light shade; US = unshaded.

ny ones. About half of our observations found *Chamaelinorops* in full shade, and lizards were seen in full and moderate shade (the two categories with the greatest shade) in over three-quarters of all observations (Fig. 1). Indeed, only three of 70 individuals were observed in unshaded conditions, over 11 times less frequently than in full shade.

Seven lizard species are sympatric with *Chamaelinorops* at the study sites, including five species of anoles (Fig. 2). None of the other lizard species substantially overlaps with *Chamaelinorops* in its habitat preference.

The endemic Hispaniolan anguid *Wetmorena haitiana mylica* can be found in the same forest situation as *Chamaelinorops,* but is encountered only under rocks and appears to be a burrower. It occurs not only in well-shaded forest habitats but also in disturbed, open habitat, as long as there are rocks for it to hide under. The second anguid lizard at the study sites, *Celestus costatus oreistes,* is seen only in open, disturbed habitat and never is syntopic with *Chamaelinorops.*

Five species of *Anolis* are found at the study sites, and all occur primarily in ecotone habitat where the forest abruptly meets the heavily disturbed, open areas. Five of Williams's (1983) ecomorphs are represented. There are two trunk-crown ecomorph species, *Anolis coelestinus* (a trunk-crown I ecomorph species = large) and *A. singularis* (a trunk-crown II ecomorph species = small). Both occur on leaves and branches of the canopy and upper trunk of trees. *Anolis distichus* is a trunk ecomorph species, occurring primarily on tree trunks between the trunk-crown and trunk-ground species. *Anolis cybotes* is a trunk-ground species,

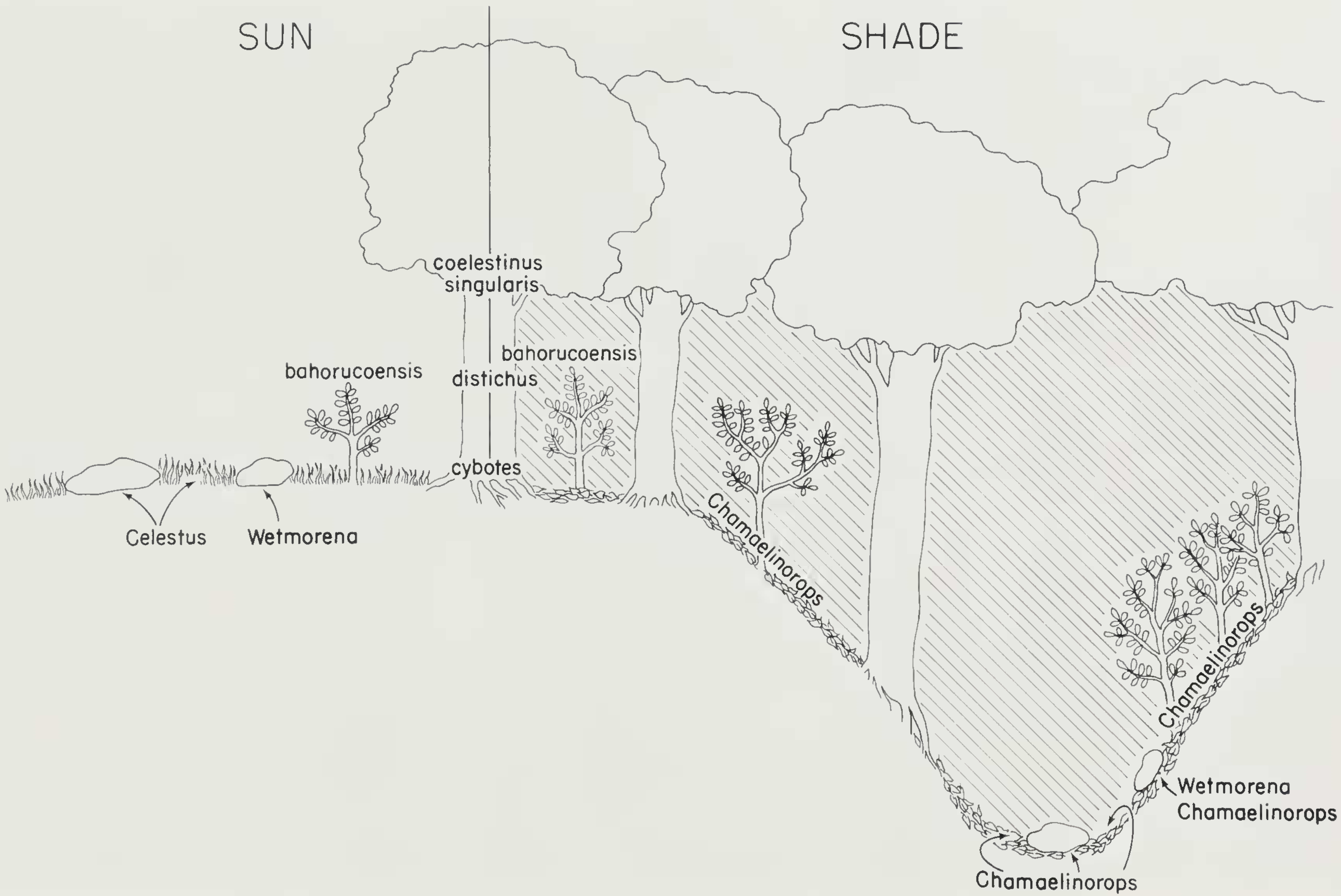
SUN
SHADE
coelestinus
singularis
bahorucoensis
distichus
bahorucoensis
cybotes
Celestus
Wetmorena
Chamaelinorops
Chamaelinorops
Wetmorena
Chamaelinorops
Chamaelinorops

TABLE 4. THERMAL BIOLOGY DATA FOR *CHAMAELINOROPS BARBOURI*.[1] T_B = BODY TEMPERATURE; T_A = AIR TEMPERATURE; N = NUMBER OF INDIVIDUALS OBSERVED; $\bar{x} \pm SD$ = MEAN PLUS OR MINUS ONE STANDARD DEVIATION; r_S = SPEARMAN'S COEFFICIENT OF RANK CORRELATION OF BODY AND AIR TEMPERATURES.

		T_B		T_A	
	N	$\bar{x} \pm SD$	Range	$\bar{x} \pm SD$	Range
Males	36	25.6 ± 1.4	22.0–31.0	22.3 ± 1.5	20.0–26.0
Females	23	26.4 ± 2.0	22.0–30.0	22.8 ± 1.5	21.0–27.0
Juveniles	3	27.5 ± 0.5	27.0–28.0	23.8 ± 2.0	22.0–26.0
Unsexed adults	2	28.2 ± 1.8	27.0–29.5	24.0 ± 1.4	23.0–25.0
Total	64	26.0 ± 1.9	22.0–31.0	22.6 ± 1.5	20.0–27.0

[1] $r_S = 0.521$ ($P < 0.001$).

occurring on the lower trunks of trees and on the ground, usually in close proximity to a tree trunk. *Anolis bahorucoensis* is found primarily on bushes (bush ecomorph). Of the five *Anolis, A. coelestinus* and *A. singularis* are rarely encountered at the study sites, and only *A. bahorucoensis* and *A. distichus* are common in or near forests inhabited by *Chamaelinorops.* Of all *Anolis, A. bahorucoensis* penetrates the forest most deeply (although still primarily an ecotone species) and on several occasions was collected on bushes in *Chamaelinorops* habitat.

Given that *Chamaelinorops* shows such a strong preference for well-shaded habitat, we were surprised to discover that its mean body temperature (MBT) is well above the mean air temperature (MAT) (Table 4 and Fig. 3). The MBT is 26.0°C, and ranges from 22.0°C to 31.0°C; the MAT is 22.6°C and ranges from 20.0°C to 27.0°C. The difference between the MBT and the MAT, $\bar{x}_{TB} - \bar{x}_{TA}$, is about 3.5°C. Linear regression of body temperature and air temperature yields a regression coefficient of 0.69, suggesting *Chamaelinorops* is more of a thermoconformer than a thermoregulator.

The very patchy abundance of *Chamaelinorops,* both spatially

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Figure 2. Perch and climatic preferences for the eight lizard species occurring at The Haitian Village study sites. Names beginning in lower case letters are species of *Anolis.* Hatched lines represent shaded habitat.

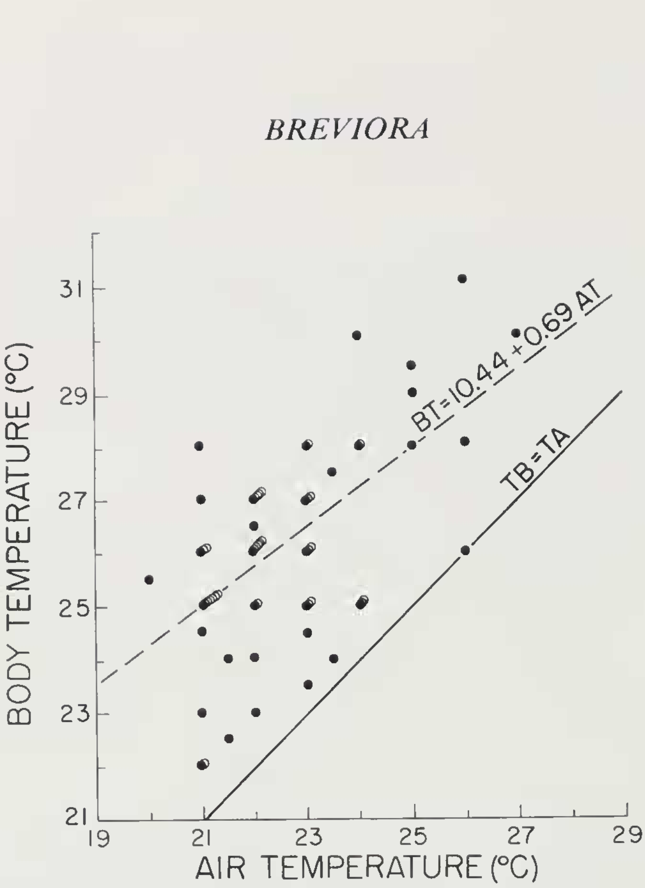

Figure 3. A plot of the body temperature and air temperature data for *Chamaelinorops barbouri.* The solid line represents the isothermal line (body temperature = air temperature, $T_B = T_A$). The dashed line is the linear regression of body temperature and air temperature, for which the equation is provided. The correlation coefficient (r_S) = 0.52. Multiple individuals with the same data are depicted by overlapping circles.

and temporally, was impressive. *Chamaelinorops* only occurs in the selected areas around The Haitian Village where its stringent habitat requirements are met; elsewhere in the area it appears to not occur at all. It is abundant only during the morning hours and early afternoon; after 1400 hrs, *Chamaelinorops* completely disappears. Additionally, even when we visited ideal habitat at ideal hours where the previous day *Chamaelinorops* had been found in abundance, on some occasions, it was difficult or impossible to find any lizards.

Data on behavior is limited, primarily due to the sedentary habits and cryptic nature of *Chamaelinorops.* We often attempted to observe individuals in the field, but were continually rewarded with nothing but a prolonged view of an immobile lizard (even after up to 15 minutes of observation). Observations on captive individuals yielded similar results. We became most familiar with *Chamaelinorops* escape behavior, which usually consists of a very brief scampering dash or series of hops (of no more than several inches) followed by an abrupt freeze. This tactic proves quite effective: the leaf litter, bare earth, and crushed limestone background beautifully conceal a stationary *Chamaelinorops* with its color pattern of black markings on pale white, gray, and tan tones, and an outline that closely resembles a dead leaf. When pressed further, *Chamaelinorops* often dives into the leaf litter. If it does not dive into the leaf litter, *Chamaelinorops* continues its initial tactic of a brief dash or series of hops followed by an abrupt stop, starting and stopping until the threat abates or an object to hide behind is encountered. When subjected to a prolonged threat, *Chamaelinorops* seems to tire quickly, increasingly abbreviating the flight and extending the stationary portion of the escape.

When captured, males can be quite aggressive, holding out the stark black dewlap, opening the mouth to expose the black mucosa, and even producing a weak bite if greatly agitated. Females and juveniles were never observed exhibiting such behavior when captured, and indeed one could reliably identify a male by such aggressive behavior alone. *Chamaelinorops* also moved abruptly and became quite agitated when one of us produced high-pitched whistles and bird-like clicking sounds (resembling the call of grackles).

Although no behavioral interactions were observed in the field, on several occasions multiple individuals were found together in a small area, including one observation of five individuals in a three by three meter area. One question which still remains unsettled is whether *Chamaelinorops* burrows. One individual was found under several inches of sandy soil and stones, and several were collected under rocks and leaf litter (Table 2). Residents of The Haitian Village believe *Chamaelinorops* burrows, and we were shown holes in which lizards were believed to live. However, we never found lizards after excavating such holes, and in captivity individuals were never observed to burrow despite being provided with ample soil in terraria.

DISCUSSION

General Ecology. Chamaelinorops barbouri is the only known West Indian anole specialized for life in leaf litter. Indeed, of all the anoles, only *Anolis humilis* from Central America approaches *Chamaelinorops* in its preference for leaf-litter habitat (Brattstrom

TABLE 5. *CHAMAELINOROPS BARBOURI* AND *ANOLIS HUMILIS* COMPARED. DATA FOR *A. HUMILIS* IS FROM FITCH (1973, 1975).

Feature	*Chamaelinorops barbouri*	*Anolis humilis*
Snout–vent length	Usually <50 mm	<45 mm
Color	Light brown/tan with variable pattern	Dark brown/olive with variable pattern
Dewlap	Small, black with yellow edge	Large, red with yellow edge
Modal perch	On ground, mostly leaf litter, marked shade preference	Often leaf litter, but mostly above ground on buttressed roots of large trees; marked shade preference
Body proportions	Head relatively short, body compressed, long limbs, very long tail	Stout body, short limbs and tail
Scales	Middorsal scales greatly enlarged, keeled, 4–10 rows	Middorsal scales greatly enlarged, keeled, 8–12 rows
Foraging behavior	Sit-and-wait predator (?) on ground	Active forager on ground and buttressed roots of large trees
Defensive behavior	Primarily crypsis, via immobility, start and stop flight; always flees on ground, never climbs	Primarily crypsis, via start and stop flight; always flees towards tree root buttresses on ground or climbs tree base

and Howell, 1954; Fitch, 1973, 1975; Talbot, 1977). *Anolis humilis* exhibits several similarities to *Chamaelinorops* (Table 5), including small size, elements of the color pattern, yellow edging of the dewlap, preference for leaf litter and shade, greatly enlarged keeled middorsal scales, aspects of escape behavior, and absence of basking behavior (Fitch, 1973, 1975). However, the two anoles differ markedly in a number of other features which directly reflect the greater specialization of *Chamaelinorops* for life in leaf litter. *Chamaelinorops* is exclusively terrestrial and predominantly found in leaf litter, whereas *A. humilis* spends much of its time above ground and, when in leaf litter, is almost always centered around buttress roots of large trees. *Chamaelinorops* relies more on staying immobile or hiding, and flees only on the ground; *A. humilis* is much more mobile and usually flees toward trees, occasionally "squirreling" around the tree base to the opposite side of the threat. In form, *Chamaelinorops* more closely resembles a dead leaf, with the "body extremely compressed, the sides vertical or concave . . ." (Schmidt, 1919) and an overall angular appearance, compared to the "stubby-bodied" (Fitch, 1975) *A. humilis.* So, in every way—ecologically, behaviorally, and morphologically—*Chamaelinorops* is more specialized for life in leaf litter than *A. humilis.* Indeed, *Chamaelinorops* is the only known true leaf-litter specialist among all of the anoles for which ecological information is available.

Although no other West Indian anole is a leaf-litter specialist, three species are known to be as markedly terrestrial as *Chamaelinorops. Anolis armouri* and *A. shrevei* of the Dominican Republic are commonly found under stones, and *A. armouri* also perches horizontally on fallen logs (E. E. Williams, in lit.). Ruibal (1964) provided a description of the habitat preferences of the Cuban *A. ophiolepis,* which is of interest in comparison to *Chamaelinorops*: "This is not a rare species; it is merely rarely caught. This is the only truly terrestrial species of the Cuban anoline lizards. The species is found in pastures and savannas, on the ground and runs to take refuge in grass tussocks. I have observed the species sleeping on the leaves of small bushes."

We tentatively suggest that the shared terrestrial habitat preferences and behaviors seen in *Chamaelinorops* and these three *Anolis* may represent a "weak" ecomorph, a "ground" category. Certain anole ecologies, such as a preference for ground habitat, may not select for strong, completely congruent behavior and/or morphology. This may reflect the great variability of ground habitats (in soil types, cover such as leaf litter versus grass, open surfaces versus dense undergrowth, to name a few) as compared to a more uniform surface such as a tree trunk. Thus, these four "ground" anoles, although alike in their terrestriality and particular behaviors, are morphologically different, in contrast to the "standard sequence" ecomorphs (Williams, 1983) which show strong correlations among morhpology, ecology, and behavior.

Data on perch height preference in *Chamaelinorops* show that it is an exclusively terrestrial anole. In situations where it was not clear whether an individual might have chosen a perch above ground level, we always decided in favor of the greatest perch height category possible. However, in all five such observations, stone or boulder perches were involved which closely resembled the ground in having leaf litter and/or moss cover; furthermore, these perches never arose abruptly but were in continuous and gradual contact with the ground. Hence, to *Chamaelinorops,* such perches are probably just another varied portion of the constantly changing ground surface. If *Chamaelinorops* ever climbs above the ground, it appears to be a rare exception.

The observations of others (Schwartz and Inchaustegui, 1980; Franz and Cordier, 1986) are largely in agreement with our data, except some cases of use of low arboreal perches have been noted. Schwartz and Inchaustegui (1980) reported that all but two specimens for which they had information came from ground situations; one individual was found "... at night sleeping totally exposed on the curving bare branch of a small woody legume 0.3 m above the ground surface," and another was "... in a crevice in a large tree about 1.2 m above the ground in a field being actively cut and weeded by a number of native workmen." Franz and Cordier (1986) found all but three and their specimens in ground situations; three specimens were collected "... among twigs in dead shrubs," but no perch height was provided.

Our data suggest that observations of diurnal arboreality in *Chamaelinorops* probably represent extreme circumstances or unusual instances. Our experiences suggest that the individual found 1.2 m above the ground in a large tree (Schwartz and Inchaustegui, 1980) may have been driven there by severe, immediate habitat destruction and disturbance, a situation and response unlikely to be observed under more natural conditions. The three individuals found among twigs in dead shrubs (Franz and Cordier, 1986) may actually have been on the ground within the matted twigs, a situation we frequently encountered. However, a sleeping individual found on a low arboreal perch (Schwartz and Inchaustegui, 1980) may represent either the true perch choice for sleeping *Chamaelinorops,* as is the case with most anoles, or unusual circumstance; we failed to observe *Chamaelinorops* sleeping, and, to date, this single observation is the only published report available.

The habitat preferences of *Chamaelinorops* appear to be rigidly specific. We believe that the specific habitat requirements we observed will be closely adhered to wherever *Chamaelinorops* is encountered, perhaps varying in the presence of a small stream, or the absence of a dry stream bed (but under mesic conditions). Although our study sites were in montane broadleaf forest canopy, it is not surprising that *Chamaelinorops* has also been found in montane pine forest (Franz and Cordier, 1986), the other type of Hispaniolan forest at higher elevations. In Haitian pine forest, Franz and Cordier (1986) found *Chamaelinorops* in ground situations, particularly in association with dead pine needles—the "leaf litter" of pine forests—and among their locality data ravines and basins are mentioned. Schwartz and Inchaustegui (1980) also noted *Chamaelinorops* in association with ravine habitat.

The patchy abundance of *Chamaelinorops,* both spatially and temporally, is striking. Its activities are apparently limited by the time of day and microhabitat requirements, and vary from one day to the next. Given the elusive habits and cryptic nature of *Chamaelinorops,* it is no wonder that, for decades, only experienced residents could collect it in any abundance.

Behavior. Although the sedentary nature, cryptic coloration, and elusive habits of *Chamaelinorops* prevented all but the most cursory portrait if this anole's behavior, some generalizations became apparent. Defensive behavior is based primarily on the use of camouflage and hiding: *Chamaelinorops* relies on immobility or short, abrupt starts and stops, along with leaf litter and other objects for hiding. Although foraging behavior was not observed, we suspect, as Schwartz and Inchaustegui (1980) have suggested, that *Chamaelinorops* is probably a "sit-and-wait" predator rather than an active pursuer, since its camouflage and sedentary tendencies well suit it for such a predation mode.

Whether *Chamaelinorops* burrows, as is claimed by residents of The Haitian Village, is still unclear. Supporting such claims is the observation of an individual under several inches of soil, and the testimony of several local residents. Contradicting these claims was our failure to unearth *Chamaelinorops* from alleged burrows pointed out to us by residents, and a lack of evidence of burrowing activity in any of the many individuals observed in captivity.

The possibility of burrowing lends an attractive potential functional explanation for the peculiar, extremely ossified vertebral column of *Chamaelinorops,* particularly in light of the resemblance of its vertebral column to that of only one other vertebrate, the mole *Scutisorex* (see Allen, 1917). However, as discussed above, the data available on burrowing is far from conclusive and the issue clearly deserves further investigation. Böhme (1982) hypothesized that the bony dorsal "shield" found in *Chamaelinorops* and certain chameleons of the genus *Brookesia* serves to deter bird predation by maintaining immobility and rigidity after being struck by a bird's beak. However, we observed conspicuous agitation and alarm elicited in *Chamaelinorops* in response to bird-like whistles and clicks, suggesting *Chamaelinorops* most likely responds to threatened bird predation in a more active than passive fashion. Besides a number of bird species, other potential predators encountered at the study sites are the colubrid snake *Antillophis parvifrons* and very large centipedes common under rocks.

It is clear from our discussion of *Chamaelinorops* behavior that it is quite difficult to obtain useful behavioral data on this cryptic, inactive, and highly elusive anole; ethological studies are patently needed but will demand the utmost in patient, careful observation and perseverance.

Themoregulation. Chamaelinorops was never encountered basking during this study. The possibility might be raised that we failed to observe basking because the exceptional camouflage of these lizards caused us to overlook some individuals, or startle tactics necessary for locating *Chamaelinorops* resulted in individuals moving out of sun patches too quickly for us to note basking. However, although we actively searched for *Chamaelinorops* in sun patches throughout the study, basking behavior was not observed (the three individuals observed in unshaded circumstances did not exhibit "classic" lizard basking behavior, i.e., they had not oriented and positioned their body to receive maximum solar radiation). Moreover, in the apparent preferred habitat of *Chamaelinorops,* sun patches are rare, small, and usually far apart even at midday, due to the thick forest canopy and frequent additional coffee trees, saplings or low bushes. Hence, we feel confident in stating that basking, if it occurs at all in *Chamaelinorops,* constitutes an insignificant proportion of this lizard's daily activities.

Given that *Chamaelinorops* was never observed basking and that it overwhelmingly prefers shaded deep forest habitat, the data on thermal biology is baffling (Table 4, Fig. 3). Huey and Slatkin (1976), in proposing a model of lizard thermoregulation, provided important predictions relevant to *Chamaelinorops* thermal biology: (1) Thermoregulation is beneficial only when associated costs are low. (2) The cost of raising body temperature should be proportional to the distance necessary for shuttling between sun and shade or hot and cold microenvironments. Thus, the cost of raising body temperature should be greater in closed forests than in more open habitats. (3) Lizards living in shaded forests (excluding the canopy), where costs of raising body temperature should be much higher than in open habitats (patches of sun for basking are more widely spaced in forests), tend not to bask and seemingly are relatively passive to ambient conditions. *Chamaelinorops* occurs exclusively in closed forests where patches of sun are few and far between; furthermore, *Chamaelinorops* shows a predominant preference for shade within such forest habitat (Fig. 1). Hence, the distance necessary for shuttling between sun and shade in *Chamaelinorops* habitat is great, and so is the cost of thermoregulation, by prediction (2) above. Since the thermoregulation is beneficial only when associated costs are low, *Chamaelinorops,* like many other lizards in shaded forests (Huey and Slatkin, 1976), should tend not to bask and should be relatively passive to ambient conditions. As one might predict, no basking behavior was observed, and *Chamaelinorops* was expected to be quite a thermoconformer, maintaining a body temperature varying little from ambient temperature.

However, as the data graphically and surprisingly depict (Table 4, Fig. 3), *Chamaelinorops* clearly maintains a body temperature well above air temperature, with the value of $\bar{x}_{TB} - \bar{x}_{TA}$ approximating 3.5°C. These data are even more impressive when compared with similar thermal data on other anoles (Table 6). Noteworthy is that the value of $\bar{x}_{TB} - \bar{x}_{TA}$ of *Chamaelinorops* greatly exceeds that of all the mainland shade-loving forest anoles for which data are available, and also well exceeds that of *Anolis allogus, A. gundlachi,* and *A. lucius,* the only purely shade-loving Greater Antillean forest anoles for which such data are available. Indeed, the $\bar{x}_{TB} - \bar{x}_{TA}$ of *Chamaelinorops* exceeds that of all but

Table 6. Comparison of the thermal biology of *Chamaelinorops barbouri* with all Greater Antillean and mainland shade-dwelling forest anoles for which appropriate data are available. $X_{TB} - X_{TA}$ = difference between mean body temperature and mean air temperature; regression coefficient = slope of the linear regression of body temperature and air temperature; NA = not available. With the exception of *C. barbouri*, all species listed are *Anolis*.

Species	$\bar{X}_{TB} - \bar{X}_{TA}$	Regression coefficient	Habitat	Reference
West Indian species				
Chamaelinorops	3.4	0.69	Deep-forest shade	This study
allisoni	0.8–1.6	NA	Open sunny areas	Ruibal, 1961
allogus	−0.8–−0.9	NA	Deep-forest shade	Ruibal, 1961
cooki	1.8	NA	Open, xeric areas	Huey and Webster, 1976
cristatellus	1.2	0.71	Open areas	Heatwole *et al.*, 1969
cybotes	1.4–3.1	0.41–0.76	Open areas	Hertz and Huey, 1981
distichus	NA	0.63	Mostly closed, shaded forest	Lee, 1980
gundlachi	0.4–0.5	1.08–1.13	Deep-forest shade	Hertz, 1981
homolechis	0.1–1.1	NA	Edge situations	Ruibal, 1961
longitibialis	1.1	0.83	Shaded portions of xeric areas	Hertz and Huey, 1981
lucius	−0.5–−0.9	NA	Deep forest shade	Ruibal, 1961
olssoni	2.3–3.1	0.7–0.89	Arid grassland and shrub	Hertz, 1974
sagrei	0.8-1.5	0.61–0.96	Open and closed areas	Lee, 1980; Ruibal, 1961
semilineatus	2.2–2.5	0.74–0.85	Mesic grassland and riparian	Hertz, 1974
shrevei	7.1	0.35	High montane grassland	Hertz and Huey, 1981
stratulus	0.9	0.77	Open park	Heatwole *et al.*, 1969

TABLE 6. Continued.

Species	$\bar{X}_{TB} - \bar{X}_{TA}$	Regression coefficient	Habitat	Reference
Mainland forest species				
gemmosus	0.6	NA	Cloud forest	Fitch *et al.*, 1976
humilis	1.0	NA	Deep-forest shade	Fitch, 1973
nigrolineatus	−0.6	NA	Cacao trees	Fitch *et al.*, 1976
polylepis	1.8	0.93	Deep-forest shade	Hertz, 1974
scypheus	1.1	NA	Rain forest	Fitch, 1968
taylori	1.2	NA	Dense woods	Fitch *et al.*, 1976

one Greater Antillean *Anolis, A. shrevei,* which is known to bask frequently (Hertz and Huey, 1981), in contradistinction to our observations on *Chamaelinorops.* Similarly, the regression coefficient of the linear regression of body temperature and air temperature for *Chamaelinorops,* 0.69, puts it distant to non-basking, shade-loving anoles like the Costa Rican *A. polylepis* (regression coefficient = 0.93; Hertz, 1974) or the Puerto Rican *A. gundlachi* (regression coefficient = 1.08–1.13; Hertz, 1981), but close to average for an open habitat, basking Greater Antillean anole, such as *A. cristatellus* or *A. cybotes* (Table 6). Hence, given that a regression coefficient of 0 represents perfect thermoregulation and 1 perfect thermoconformity (Huey and Slatkin, 1976), *Chamaelinorops* appears to be thermoregulating much more than it "should" be.

Chamaelinorops appears to be a shade-loving, non-basking anoline lizard that inhabits deep montane forest where sun patches are rare and costly to get to. How can it, then, maintain such a high value for $\bar{x}_{TB} - \bar{x}_{TA}$ and such a low regression coefficient for the linear regression of body temperature and air temperature? As an explanation for this enigma, three possibilities surfaced: (1) *Chamaelinorops* hides and/or sleeps beneath substrates that are warmer than air temperature. Bustard (1967) reported that geckos active at night can and may thermoregulate under bark or rock flakes during the day and achieve body temperatures near preferred levels. In order to utilize such a strategy, *Chamaelinorops* would have to use the limestone stones abundant in its habitat, in order to thermoregulate during the day. However, such stones are likely to heat up only in open habitat, not in the closed shady forest *Chamaelinorops* inhabits. (2) *Chamaelinorops* utilizes leaf litter, while both active and sleeping, to raise its body temperature. Leaf litter is a natural thermal insulator, and its decomposition generates some heat. *Chamaelinorops* could utilize the warmth retained or generated by leaf litter to raise its body temperature without necessarily having to bask. Though plausible, this explanation seems unlikely, given that leaf litter probably cannot generate adequate heat for a lizard. (3) *Chamaelinorops* may actually bask but was missed engaging in such activity during our study. This is always a distinct possibility, especially given that some deep-forest lizards, such as *Kentropyx calcaratus* (Rand and Humphrey, 1968), follow sun flecks on the forest floor. However, given that our insolation data do not indicate even the weakest correlation between *Chamaelinorops* perch selection and sun patches (Fig. 1) and that we never observed individuals sunning, we believe that this explanation may also be unlikely.

In summing up the paradoxical thermal biology of *Chamaelinorops* we can state only that resolution is not currently possible and must await more detailed study.

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